sensors capable of reading recordings with ultra-high densities in accord with the spirit and scope of the present invention as defined by the appended claims.

What is claimed is:

1. A method for forming a bottom spin valve GMR sensor element with ultra-thin layers of high density and smoothness and having sub-atomic monolayers of oxygen absorbed on the surfaces thereof, comprising:

providing, in an ultra-low base pressure sputtering chamber, a substrate;

forming on said substrate, using an ultra-low pressure Ar/O_2 mixture as a sputtering gas, a seed layer;

forming, using said sputtering gas, an antiferromagnetic pinning layer on said seed layer;

forming, using said sputtering gas, a synthetic antiferromagnetic (SyAF) pinned layer formed on said pinning layer;

forming, using only ultra-low pressure Ar as a sputtering gas, a Cu spacer layer on said SyAF layer, the surface of said spacer layer not contacting said SyAF layer then being treated with O_2 to form an oxygen surfactant layer (OSL);

forming, again using said ultra-low pressure Ar/O_2, a ferromagnetic free layer on the OSL of said treated spacer layer;

forming, using only ultra-low pressure Ar as a sputtering gas, a Ru capping layer on said ferromagnetic free layer, then forming an OSL layer on said Ru layer;

forming, using said ultra-low pressure Ar/O_2 mixture as a sputtering gas, a Ta capping layer on said Ru capping layer.

2. The method of claim 1 wherein the sputtering chamber maintains a base pressure of approximately $5x10^{-9}$ torr.

3. The method of claim 1 wherein said ultra-low pressure Ar/O_2 mixture is produced by mixing an ultra-low pressure source of high purity Ar containing oxygen in an amount less than 0.5 ppm, with the same Ar source to which between approximately 400 and 600 ppm of oxygen has been admixed, said high purity Ar being at an approximate pressure of 0.4 millitorr and said oxygen having therein a partial pressure of between approximately 10^{-9} and 10^{-8} torr.

4. The method of claim 1 wherein said antiferromagnetic pinning layer is a layer of MnPt sputtered from a source of vacuum melted MnPt containing approximately 38% Mn by atomic weight, said layer being formed to a thickness between approximately 100 and 150 angstroms.

5. The method of claim 1 wherein the synthetic antiferromagnetic (SyAF) pinned layer comprises a first layer of CoFe between approximately 17 and 21 angstroms thick, on which is formed a Ru coupling layer of approximately 7.5 angstroms thickness, on which is formed a second layer of CoFe between approximately 18 and 22 angstroms thick.

6. The method of claim 1 wherein the non-magnetic spacer layer is a layer of Cu between approximately 16 and 20 angstroms thick.

7. The method of claim 1 wherein the OSL is formed by treating the Cu layer with an oxygen dose of approximately 10^{-4} torr.-sec in a separate chamber.

8. The method of claim 1 wherein the ferromagnetic free layer is a double layer comprising a layer of CoFe between approximately 8 and 12 angstroms thick on which is formed a layer of NiFe between approximately 13 and 18 angstroms thick.

9. The method of claim 1 wherein the Ru capping layer is formed between approximately 5 and 10 angstroms thick and an OSL is formed thereupon in a separate chamber.

10. The method of claim 1 wherein the Ta capping layer is formed between approximately 10 and 3 0 angstroms thick.

11. The method of claim 1 wherein said seed layer is a layer of NiCr, having 40% Cr by atomic weight and being formed to a thickness between approximately 35 and 45 angstroms.

12. The method of claim 1 wherein said seed layer is a double layer, comprising a layer of NiFeCr having approximately 40% Cr by atomic weight and of thickness between approximately 35 and 40 angstroms on which is formed a layer of NiFe of thickness between approximately 7 and 10 angstroms.

13. A bottom spin valve GMR sensor element having ultra-thin layers of high density and smoothness with sub-monolayer thick surface oxygen layers thereon, comprising:

a substrate;

a seed layer formed on said substrate;

an antiferromagnetic pinning layer formed on said seed layer;

a synthetic antiferromagnetic (SyAF) pinned layer formed on said pinning layer;

a Cu spacer layer formed on said SyAF layer, the surface of said spacer layer not contacting said SyAF layer having an oxygen surfactant layer (OSL) formed thereupon;

a ferromagnetic free layer formed on the OSL of said spacer layer;

a Ru capping layer formed on said ferromagnetic free layer, the surface of said Ru layer not contacting said free layer having an OSL formed thereupon;

a Ta capping layer formed on said Ru capping layer; and

wherein said seed layer, said pinning layer, said pinned layer and said free layer each have an OSL inherently formed thereon as a result of the incorporation of oxygen during their formation.

14. The element of claim 13 wherein said antiferromagnetic pinning layer is a layer of MnPt sputtered from a source of vacuum melted MnPt containing approximately 38%

Mn by atomic weight, said layer being formed to a thickness between approximately 100 and 150 angstroms.

15. The element of claim 13 wherein the synthetic antiferromagnetic (SyAF) pinned layer comprises a first layer of CoFe between approximately 17 and 21 angstroms thick, on which is formed a Ru coupling layer of approximately 7.5 angstroms thickness, on which is formed a second layer of CoFe between approximately 18 and 22 angstroms thick.

16. The element of claim 13 wherein the non-magnetic spacer layer is a layer of Cu between approximately 16 and 20 angstroms thick and the OSL is less than an atomic mono-layer thick.

17. The element of claim 13 wherein the ferromagnetic free layer is a double layer comprising a layer of CoFe between approximately 8 and 12 angstroms thick on which is formed a layer of NiFe between approximately 13 and 18 angstroms thick.

18. The element of claim 13 wherein the Ru capping layer is formed between approximately 5 and 10 angstroms thick.

19. The element of claim 13 wherein the Ta capping layer is formed between approximately 10 and 30 angstroms thick.

20. The element of claim 13 wherein said seed layer is a layer of NiCr, having 40% Cr by atomic weight and being formed to a thickness between approximately 35 and 45 angstroms.

21. The element of claim 13 wherein said seed layer is a double layer, comprising a layer of NiFeCr having approximately 40% Cr by atomic weight and of thickness between approximately 35 and 40 angstroms on which is formed a layer of NiFe of thickness between approximately 7 and 10 angstroms.